U. S. Department of Agriculture
Soil Conservation Service
Engineering Division

Technical Release No. 32
Geology
July 1966

PROCEDURE FOR DETERMINING RATES OF LAND DAMAGE, LAND DEPRECIATION AND VOLUME OF SEDIMENT PRODUCED BY GULLY EROSION

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General

This technical release provides a guide to the determination of future rates of potential land damage, land depreciation and sediment produced by gully erosion. The term "gully," as used in this guide, includes upland and valley side-wall gullies as well as incising channels within flood plains commonly called valley trenches. Justification of structural measures for gully stabilization is based on a reduction of expected future damages.

The method presented is acceptable for adjusting the historical rate of growth to the probable future rate on the basis of measurable conditions above an advancing headcut. Each of the primary factors influencing the rate of gully erosion is considered and incorporated to the extent possible in this procedure. Where quantitative values are not assigned to specific factors, criteria are provided to aid the geologist in selecting proper values. The procedures set forth here are the minimum technical standards for SCS work to be used to predict the future rate of development of an existing gully and to estimate the area of land voided and the location and area of land depreciated.

The use of this procedure is not required for estimating sediment yield for determining storage requirements for sediment accumulation in floodwater or other structures designed or constructed by the SCS. An alternate procedure for this purpose is to be outlined in a forthcoming technical release entitled, "Procedures for the Determination of Sediment Sources, Gross Erosion, and Sediment Delivery Ratios."

This method is most applicable to areas east of the Rocky Mountains, a narrow belt along the Pacific Coast, and for higher mountainous areas in the west. The geologist should consult with the EWP Unit geologist for a suitable procedure to compute gully growth in arid areas.

Nature of Damage Resulting from Gully Erosion

Methods of evaluating damage resulting from gully erosion are outlined in the Economics Guide, Chapter 5, Sediment and Erosion Damage. The following types of damage are evaluated with respect to gully erosion.

Land Damage

Land damage by gully erosion is a permanent nonrecoverable damage. Land damage is physically expressed by the geologist in terms of the area eroded or "voided" by a gully or gully system.

Land Depreciation
Land depreciation is the loss of net income due to a lower level of production and pattern of land use associated with gully erosion. Land depreciation occurs on physically undamaged land adjacent to, or influenced by, a gully.

Sediment Damage
Sediment damage is damage which occurs to downstream enterprises by deposition of sediment or sediment in transport. Examples of sediment damage are deposits on land, streets and roads; swamping; deposition in reservoirs and channels; and increased water filtration costs.

Conditions Influencing Gully Erosion

Gully development is initiated as a result of changes in conditions which influence the hydraulic characteristics of flow or the forces that resist erosive flows. Once the gully channel is established, the resulting concentration of flow is sufficient to sustain gully erosion. Subsequent headward erosion and widening will continue until the gully is adjusted to a new set of equilibrium conditions and becomes relatively stable.

In general, the annual rate of gully advance is variable, being more rapid at some stages in its life cycle than in others. Observations indicate that the rate of advancement progressively decreases in the final stages of development. The factors that influence the rate of gully advancement at any period in its life history are varied and complex. Our knowledge of the relative importance of the causal factors has not progressed to the extent that precise quantitative values can be placed on all of the variables believed to be significant in gully erosion. Consequently, adequate prediction of the rate of advancement depends largely upon the experience and judgment of the geologist in recognizing controlling factors and assigning proper quantitative values to those factors which have not yet been statistically evaluated.

Experience has shown that the prediction of the future rate of gully advancement, based on the historical rate alone, can lead to serious errors of prediction and evaluation unless proper consideration is given to those factors which may have a major influence on the rate of advancement. Condition factors such as the characteristics of the geologic materials, topography, land use, and volume of runoff control the rate of gully advance. A change in conditions above an advancing gully head changes the rate of advancement.

The influence of these factors on the rate of headward advancement is recognized. However, in this procedure only the relationships involving area and precipitation were used. These were developed as a result of SCS field measurements on 210 gullies in six widely scattered land resource areas east of the Rocky Mountains in the

United States. One of the analytical results of these studies was reported previously. [1] The following relationship between headward advancement and the primary causal factors was found from a more recent analysis: [2]

$$R = 1.5\ (W)^{.46}\ (P_{0.5})^{.20} \qquad [1]$$

where

- R = rate of headward advancement, in feet per year
- W = average drainage area above headcut, in acres
- $P_{0.5}$ = the summation of 24-hour rainfalls of 0.5 inch or greater occurring during the life of the gully, converted to an average annual basis, in inches.

At least four other factors, not included in the foregoing measurements, are known to influence the rate of headward advancement of gullies. These are: (1) changes in erodibility of soil material through which the gully advances, (2) the slope of the approach channel above the headcut, (3) changes in runoff due to changes in land use and practices in watershed and (4) the influence of ground water. Judgment must be used in adjusting for the effect of these factors on the future rate of gully head advance as determined from the procedure given below.

With the foregoing knowledge and using the principle of proportions, it is possible to establish an equation for predicting the future rate of headward erosion, if the past rate is known and the future changes in conditions can properly be anticipated. The prediction equation is as follows:

$$R_f = R_p\ (A)^{.46}\ (P)^{.20} \qquad [2]$$

where

- R_f = computed future average annual rate of gully head advance for a given reach, in feet per year
- R_p = past average annual rate of gully head advance, in feet per year
- A = ratio of the average drainage area of a given upstream reach (W_f) to the average drainage area of the reach through which the gully has moved (W_p)
- P = ratio of the expected long term average annual inches of rain from 24-hour rainfalls of 0.5 inch or greater (P_f) to the average annual inches of rain from 24-hour rainfalls of 0.5 inch or greater for the period, if less than 10 years, in which the gully head has moved (P_p)

1/ Thompson, J.R., 1964, "Quantitative Effect of Watershed Variables on Rate of Gully-Head Advancement" Trans. of ASAE, Vol. 7, No. 1, pp. 54-55.

2/ Data analyzed by the Statistical Reporting Service, USDA, Washington, D. C.

Equation 2 should be used in estimating the future rate of development of gullies for determining, on the basis of potential future damage, the extent of expenditures which could be justified in any specific case. Stabilization of a gully in the initial stages of development with high potential future damage can normally be economically justified. The same control measures for a gully which has practically reached its maximum stage of development normally cannot be economically justified.

Gully erosion consists of headward advance, upstream migration of secondary knickpoints, and widening of the gully channel. In computing and analyzing rates of development for projection into the future, each of these types of growth should be considered separately.

Each advancing head, whether main or lateral, should be treated independently. Also, when the drainage entering a head indicates the probability of tributary gully development, the potential development of gully heads in these tributaries should be considered and their estimated rate of growth calculated.

Values for Factors in the Equation

Past Rate of Gully Erosion

In the use of this procedure the past annual rate of gully advance, or the R_p value must be determined. This is the reach of existing gully indicated as reach A-B in figure 1. The length of the gully advancement is determined by use of aerial photographs, maps, field inspection or other methods. The age is established by interview, inspection of old aerial photographs, or other means. "R_p," the average annual rate of headward advance in feet per year, is computed as follows:

$$R_p = \frac{\text{Gully length (ft.)}}{\text{Age of gully (yrs.)}} = \text{ft./yr.}$$

Adjustment for Change in Contributing Drainage Area

Analysis of a large number of gullies has shown that the rate of advance is related approximately to the square root of the drainage area.

Therefore, a series of reaches are delineated upstream from the present gully head for the purpose of estimating the effect of changing drainage areas on future rates of advance.

Each reach, depending on its drainage area, will have a different effect on the total runoff over the head. The ratios of the mean drainage areas of the reaches to the average drainage area of the reach through which the gully has moved (Reach A-B, figure 1) are represented by the letter "A".

$$A = \frac{W_f \text{ (Drainage Area of Upstream Reach)}}{W_p \text{ (Drainage Area of Reach A-B)}}$$

$$A^{0.46} = \left(\frac{W_f}{W_p}\right)^{0.46}$$

$A^{0.46}$ may be read directly from Figure 2.

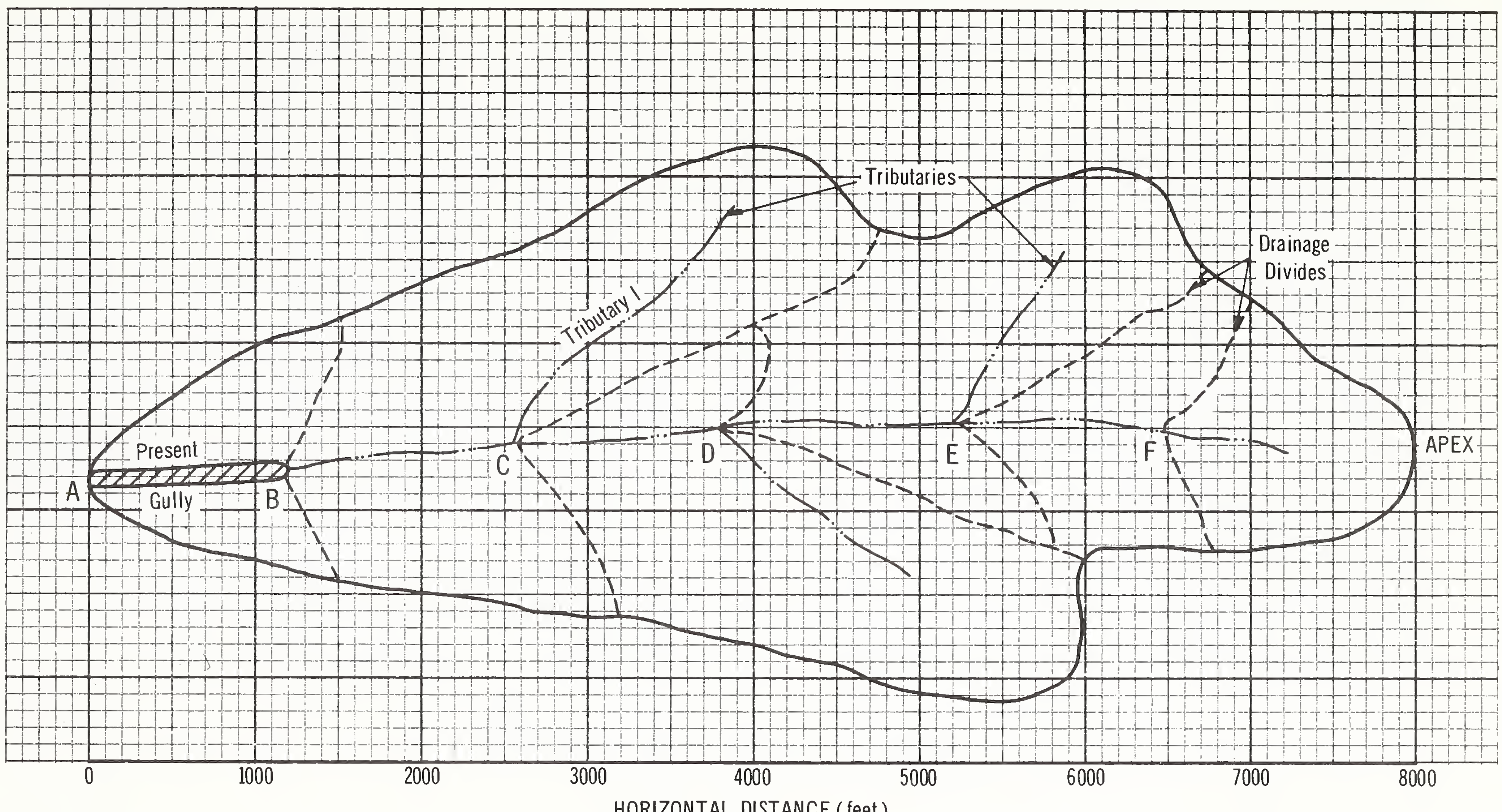

FIGURE 1 - Drainage Area of the Gully Showing the Reaches Selected, Horizontal Distance, Tributaries and Subwatersheds.

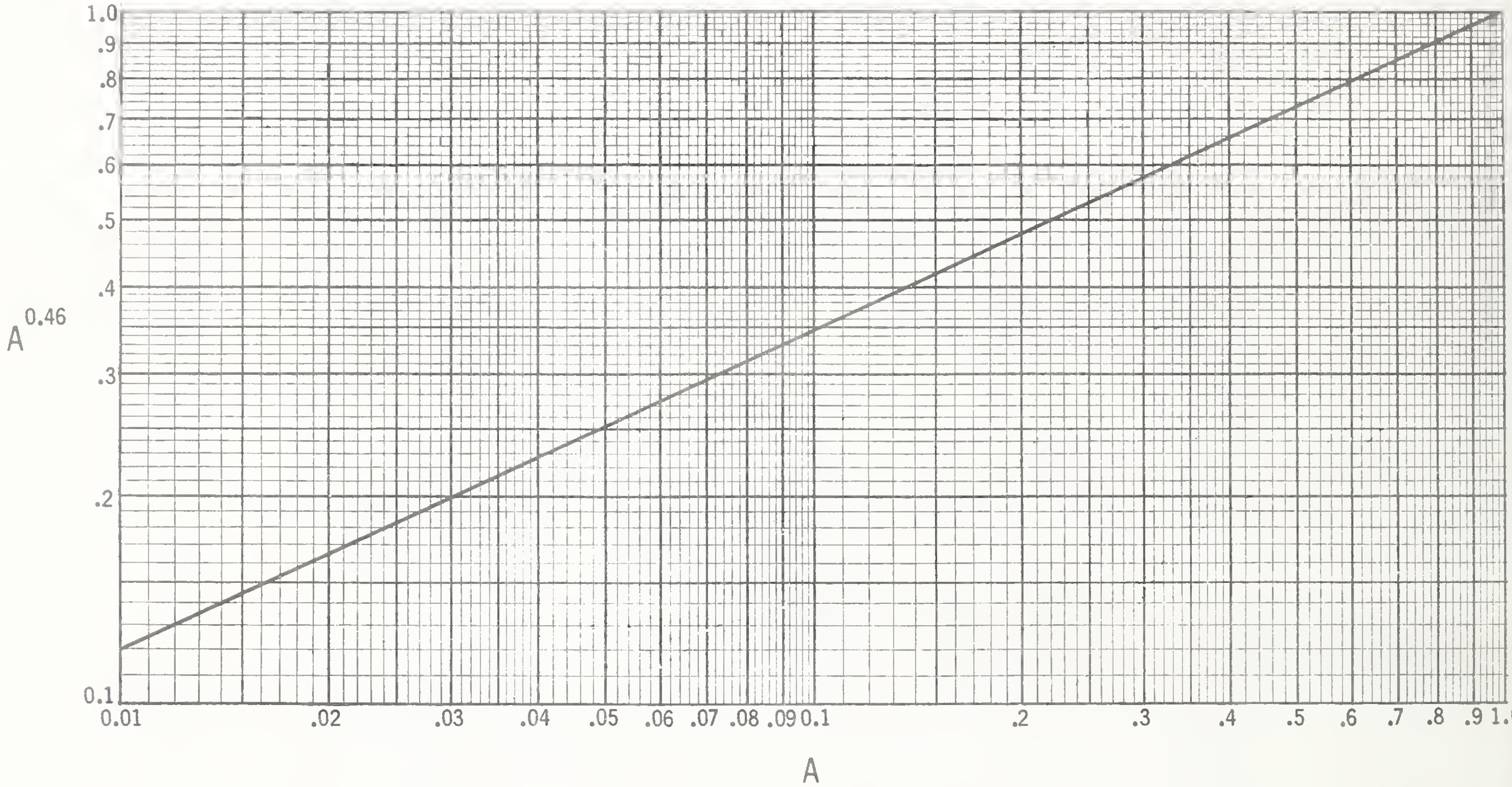

Figure 2. Graph for Obtaining the 0.46 Power of Ratio A

Adjustment for Precipitation

The precipitation factor is a ratio that relates the expected future long-term average precipitation with the average annual precipitation that occurred during the advance of the present gully. The average annual rainfall of 24-hour rainfalls of 0.5 inch or greater for the past period of advance of the existing gully may be computed from published U.S. Weather Bureau data. [3]

This should be done only if the age of the gully is less than 10 years. The value for the expected future long term average annual precipitation from 24-hour rainfalls of 0.5 inch or greater may be obtained from the map shown in figure 3.

$$P = \frac{P_f}{P_p} = \frac{\text{Value selected from figure 3}}{\text{Average annual inches of 24-hour rainfalls of 0.5 inch or greater for period of advance of the existing gully.}}$$

$$P^{0.20} = \left(\frac{P_f}{P_p}\right)^{0.20}$$

Values for $P^{0.20}$ may be read directly from Figure 4.

3/ Climatological Data, U.S. Dept. of Commerce, Weather Bureau, Monthly Summaries

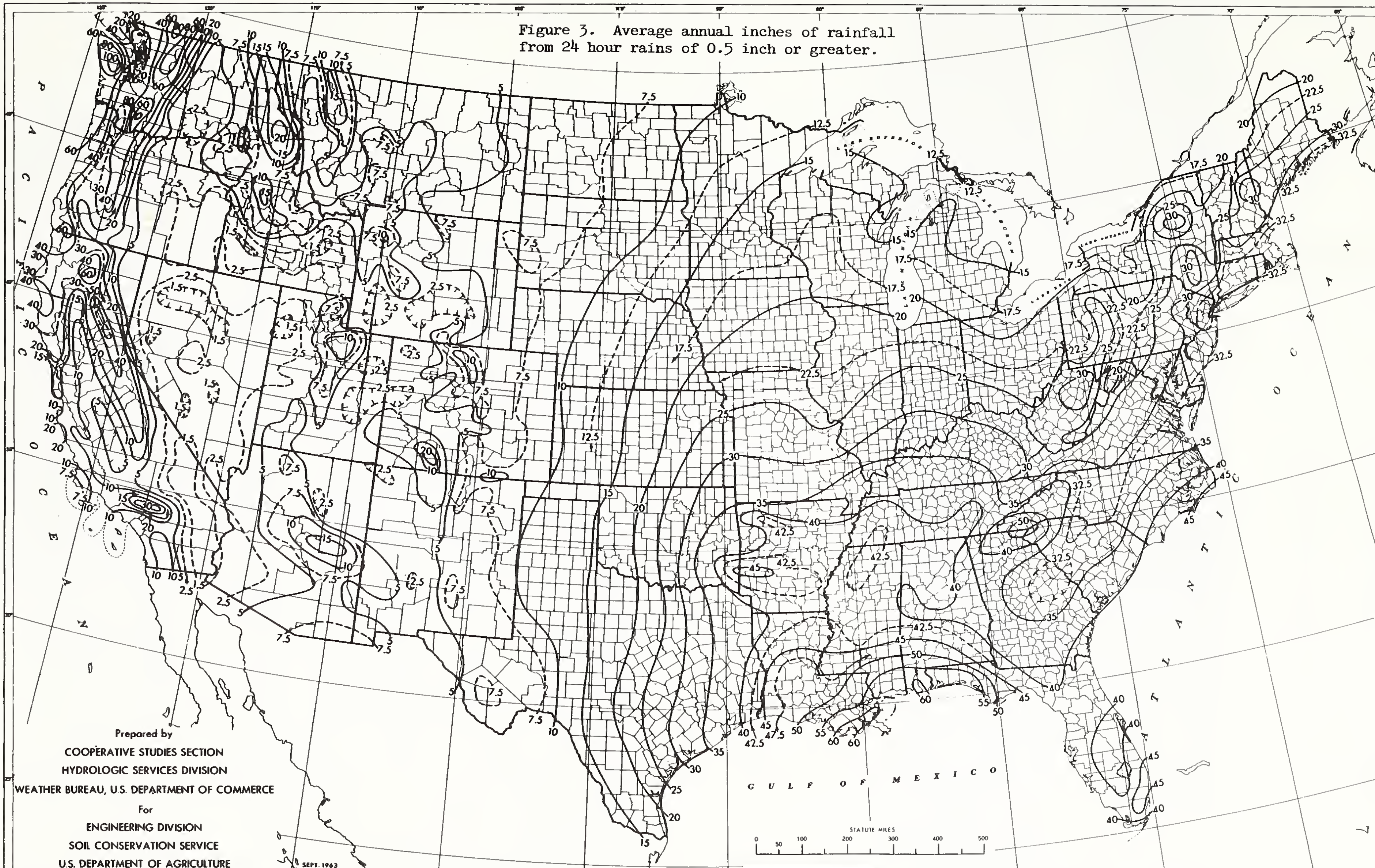

Figure 3. Average annual inches of rainfall from 24 hour rains of 0.5 inch or greater.

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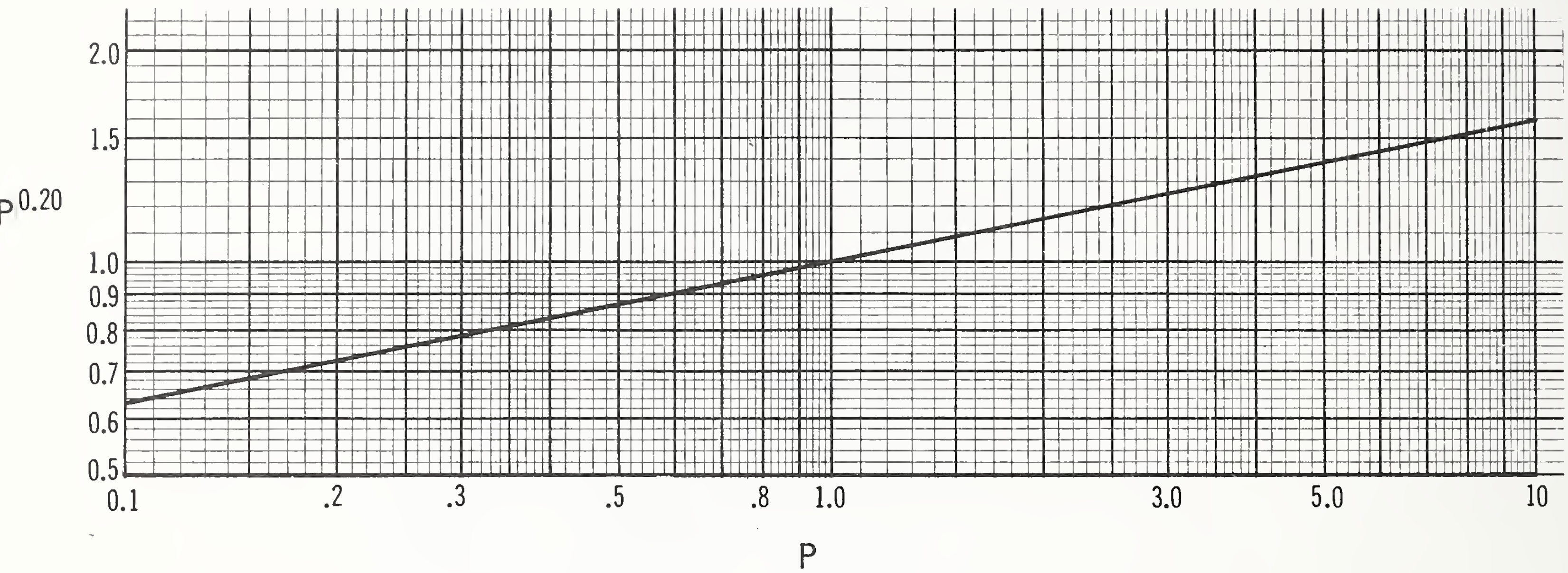


Figure 4. Graph for Obtaining the 0.20 Power of Ratio P

Adjustment for Type of Material

If the future gully will advance through materials similar to those in which it advanced in the past, there will be no change in the rate of advancement due to change of materials and no adjustment is needed. The value may be greater or less than 1.0 if a significant change in the soil materials exists upstream from the present gully. If the composition of the materials in the upstream reaches has a smaller proportion of clay material, it is generally more erodible and a factor greater than 1 should be used. If the material becomes more cohesive in the upstream reaches, it is generally more resistant to erosion and the adjustment of future advancement would be downward (less than 1). Adjustments are made by multiplying the computed rate of advance and the adjustment factor.

Adjustment for Ground Water

The rate of gully head advancement may change if the gully head intersects a water table or a gully channel emerges above a water table. Observations indicate that the rate of gully head movement may be accelerated in zones where ground-water seep exists at the foot of the overfall or may slow down when progressing above a water table. No quantitative measurements are known which evaluate the effects of ground-water on the rate of gully head movement. Where no change in ground-water conditions is anticipated, no adjustment should be made. Where a gully head intercepts a water table, or where the water table is expected to rise due to land treatment measures, the rate may require an adjustment upward. Conversely as a gully advances it may rise above the water table and require a downward adjustment in the rate.

Each gully must be evaluated as a separate case in terms of the characteristics of the materials, stratigraphy, and ground-water conditions. Judgment must be used in assigning a realistic value. Adjustments are made, as for the type of material mentioned, by multiplying the computed rate of advance by the ground-water adjustment factor.

Method of Estimating Future Rates of Gully Advancement

The following is a step-by-step procedure demonstrating the method used to determine rates of headward advancement of gullies. A work sheet with appropriate column headings as shown in figure 5, makes a convenient form for calculating future rates of gully head advance. Figure 1 shows a schematic map of a gully for use with the following step procedure.

STEP I

a. Determine from aerial photographs, maps, and/or other sources the length of gully voided in a given period of time.

   Example

   Using aerial photographs, checked by rough field data, the total length of gully voided is found to be 1200 feet, Reach A-B, Figure 1.

b. Determine by interviews or other means the age of the gully.

   Example

   Age of gully = 15 years

c. Compute the past average annual rate of gully elongation.

   Example

   The average annual rate of past headward advance equals "R"

$$R_p = \frac{\text{total length of gully}}{\text{age of gully}} = \frac{1200}{15} = 80 \text{ ft./yr.}$$

d. Enter this in column 8, figure 5. "R_p" is the same for each reach delineated above the existing gully.

STEP 2

a. Using aerial photographs and/or topographic maps, draw a map with the watershed boundary of the area contributing to the gully (Figure 1).

Figure 5. Tabular Sheet for Calculation of Rates of Gully Head Advancement

(1) Reach	(2) Station	(3) Reach Length (feet)	(4) D.A. by Station (acres)	(5) Mean D.A. (acres)	(6) A	(7) $A^{0.46}$	(8) R_p (ft/yr)	(9) $P^{0.20}$	(10) [(7)(8)(9)] R_f (ft/yr)	(11) Years to Erode (3)÷(10)	(12) Accum. Years
	A		364								
A-B		1200		352	1.00	1.00	80	1.00	80	15	15
	B		339								
B-C		1400		283	0.80	.90	80	1.00	72	20	20
	C		226								
C-D		1200		182	0.52	.74	80	1.00	59	20	40
	D		137								
D-E		1400		96	0.27	.55	80	1.00	44	32	72
	E		54								
E-F		1300		43	0.12	.38	80	1.00	30	43	115
	F		31								
F-APEX		1500		16	0.05	.25	80	1.00	20	75	190
	APEX										

For 50 year evaluation period, the gully will advance:
1400 ft.*/ + 1200 ft.**/ + (10 yrs. x 44 ft.)±/ = 3040 ft. in 50 years

*/ 1400 ft. in first 20 years

**/ 1200 ft. in second 20 years

±/ 50 years - (20 yrs. + 20 yrs.) = 10 years
10 years at 44 ft/yr = 440 feet

b. Mark the location of: (1) the earliest position of the active gully (Station A) at a known date as determined in step 1a and the boundary of the area contributing runoff to this head, (2) the present position of the active gully head, B, and the boundary of the area contributing runoff to this head, (3) the selected points where the future cutting head positions may be (these future head positions will logically be located where present or potential tributaries join, where major changes in land use occur, and where probable locations of interception or departure from water tables exist as C, D, E, etc.), (4) the boundaries of areas contributing runoff to each of these points, and (5) the apex of the watershed.

c. Enter the head positions (Stations), designated A, B, C, etc. in column 2, figure 5.

d. The gully head positions or Stations are points that delineate the "reaches" (A-B, B-C, C-D, etc.). Enter reach designations in column 1 as shown in figure 5.

e. Record the horizontal distance between the head positions as the reach length in column 3, figure 5.

f. Measure the area contributing runoff to each of the gully head positions and enter these area values in column 4, figure 5.

<u>Example</u>

Station	Drainage Area (Acres)
A	364
B	339
C	226
D	137
E	54
F	31

g. Determine the mean drainage area for each reach (this is the average between succeeding stations). Enter this figure in column 5, figure 5.

<u>Example</u>

The mean drainage area for reach C-D is $\frac{226 + 137}{2} = 182$ acres.

h. Determine the A values. These are the ratios of the mean drainage area of each succeeding reach to the mean drainage area of reach A-B (reach A-B is the present gully or a segment of the present gully with a known average annual head advancement rate). Enter the A values for each reach in column 6, figure 5.

Example

The A value for reach C-D = $\frac{\text{mean drainage area of reach C-D}}{\text{mean drainage area of reach A-B}}$ =

$\frac{W_f}{W_p} = \frac{182}{352} = 0.52$

i. Using figure 1, obtain the values for $(A)^{0.46}$. Enter these in column 7 of figure 5.

Example

$A^{0.46} = (0.52)^{0.46} = 0.74$

Reach	Mean Drainage Area	[A]	$[A]^{0.46}$
A-B	352 (W_p)	1.00	1.00
B-C	283 (W_f)	0.80	.90
C-D	182 (W_f)	0.52	.74
D-E	96 (W_f)	0.27	.55
E-F	43 (W_f)	0.12	.38
F-APEX	16 (W_f)	0.05	.25

STEP 3

Consult the Monthly Summaries of Climatological Data, U.S. Weather Bureau. Select the station nearest to the gully area being evaluated. Tabulate the 24-hour rainfalls of 0.5 inch, or greater, for the period during which the present gully has advanced. Sum these values and divide by the number of years of record. This gives the average annual inches of 24-hour rainfalls of 0.5 inch or greater. Consult the map shown in figure 3 and select the appropriate value for the expected long-term average annual total 24-hour rainfalls of 0.5 inch or greater. When precipitation records for the period of gully advance equal or exceed 10 years no comparison should be made.

Example

a) In this instance, the rainfall record for the period of gully advancement exceeds 10 years. Since some points on the map (figure 3) are based on only ten years of record, no comparison is made. The ratio P equals 1 in this case. Enter this value in column 9, figure 5. The same value is used in the evaluation of each successive reach.

b) As an alternate example, assume the period of gully growth had been only five years. Then from the Monthly Summaries of Climatological Data for the general area of the gully it would be found that the summation of rains equal to or exceeding one-half inch in 24 hours for the five years of gully advancement was 95 inches. Therefore, the average annual amount of rain of one-half inch or more in 24 hours for the five years of record was 95/5 or 19 inches. From figure 3 the long-term average annual precipitation value by interpolation between lines is 18.0 inches.

$$\text{The ratio P would be } \frac{P_f}{P_p} = \frac{18}{19} \text{ or } 0.95$$

From figure 4 the 0.20 power of 0.95 is found to be .99. This value would be entered in column 9, figure 5 for future reach.

STEP 4

On figure 5, multiply the values on each line in columns 7, 8 and 9 ($A^{0.46} \times R_p \times P^{0.20}$), this product equals R_f, the calculated rate of future gully advancement, in column 10. The number of years required for the gully to pass through each reach is determined by dividing the values in column 3 by those in column 10. Enter these values in column 11. The accumulative years are entered in column 12. From these computations, the distance the gully head will advance in a 50-year evaluation period may be determined.

Example

It will take the gully head 20 years to advance through reach B-C, a distance of 1400 feet; 20 years to erode through reach C-D, a distance of 1200 feet. In the remaining 10 years it will erode at the rate of 44 feet per year into reach D-E, a distance of 440 feet.

20 yrs. + 20 yrs. + 10 yrs. = 50 yrs.
1400 ft. + 1200 ft. + (10 x 44 ft.) = 3040 ft.

The preceding procedure does not recognize any physical conditions which would hinder or stop gully advancement other than the limitation of watershed area. Certain physical barriers such as buried rock ledges may alter the advancement rate. Stabilization structures or road culverts will be the termination point of gully advancement evaluation.

Movement of Gully Heads into Tributary Drainageways

In steps 1-4 above it was estimated that the gully head would advance 3040 feet during a 50-year evaluation period. On figure 4 are shown several tributary drainageways to the main drainage. As the gully head that is advancing up the main drainage passes the junction points with the tributary drainageways, base levels of the tributaries are lowered and gully heads may begin moving up the tributaries. The rate of movement of the gully heads up the tributaries is estimated by the same method as described in steps 1-4. One difference, however, is in the time involved in the growth of the tributary gullies during the 50-year evaluation period.

Example

> Tributary I is shown to enter the main drainage at station C. It was estimated (line 4, column 11, figure 5) that the gully head in the main drainage would reach station C in 20 years. Since a gully head will not start to move up tributary I until after the gully head on the main drainage passes station C, the period for evaluating the gully advancement on tributary I will be 50 - 20 years or 30 years. The evaluation periods for the gully head movement in tributaries II and III will be of successively shorter duration.

Where a large number of tributaries exist, it may not be practical to evaluate each lateral individually. In this case, a few representative laterals should be selected for evaluation. The gully head advancement rates for the duration of the evaluation period may be extended to the remaining laterals.

Migration of Knickpoints

Compute the rate of migration of knickpoints. A knickpoint is usually the head cut of a later cycle of degradation occurring in an existing gully. Knickpoint development persists in most gully channels until the channel reaches base level. The rate of advancement of knickpoints is an important consideration from the standpoint of sediment produced as it affects the ultimate depth and, therefore, the width of the gully. In general, the same variables that affect the rate of advance of the head also influence the rate of migration of a knickpoint until equilibrium or base level is established. Beyond this state no deepening will occur. Minor widening may continue after base level is reached due to such processes as sheet erosion, animal activity, freeze-thaw and slumping.

The final grade at which a gully channel will stabilize is dependent upon the nature of materials in the channel bed and depth and velocity of flow on the channel bed. With all other conditions being equal, and considering age as an element, the gradient of a gully bed normally (except for highly erodible materials such as fine to medium-grained sand) is inversely proportional to the size of the drainage area. Thus, the smaller the drainage area the larger the gradient. The equilibrium grade or base level must, therefore, be estimated to determine the ultimate termination of knickpoint advance.

Method of Estimating Gully Widening

One method of determining the widening that will occur during the next 50 years is to project upstream the widening that has already occurred for a distance equal to the computed future headward advance.

Example

> In step 4 it was computed that the gully head would advance 3040 feet from its present location during the 50-year evaluation period. Therefore, the widening will advance

this distance upstream from its present location.

Many advancing gullies, however, do not maintain uniform top widths and depths. Often advancing secondary knickpoints widen and deepen the gully channel; the base level gradient can usually be determined by spot measurements of older, nearby gullies in the resource area.

Comparison of the top widths and depths of a large number of gullies shows the following relationships:

1. On the average, where the gully advances through cohesive materials, the gully width is about three times the depth.

2. In non-cohesive materials the gully width is about 1.75 the depth.

When a knickpoint migrates up an existing gully channel, the gully channel will widen to adjust to the new requirements for slope stability caused by deepening of the channel. Figure 6 or 7 may be used to estimate the future top width of the gully channel with the new gully depth created by a migrating knickpoint.

Example

A gully channel in cohesive materials that presently is about 15 feet deep and 45 feet wide is being deepened by a migrating knickpoint to a depth of 20 feet. Reference to figure 6 shows that the gully channel will widen to about 60 feet as a result of the 5 feet of additional depth.

Another method may be used to estimate the amount of gully channel widening that will occur. If there are numerous existing gullies in the same problem area as those to be evaluated, measurements may be made of several of these gullies to establish an average depth-top width ratio. This ratio may be used to estimate the future top-width dimensions of gullies that are undergoing change because of knickpoint migration.

Determine, by the above procedures, the total area in acres of the land estimated to be voided by the gully during the evaluation period. Also determine the rate of land loss in acres per year for the same period.

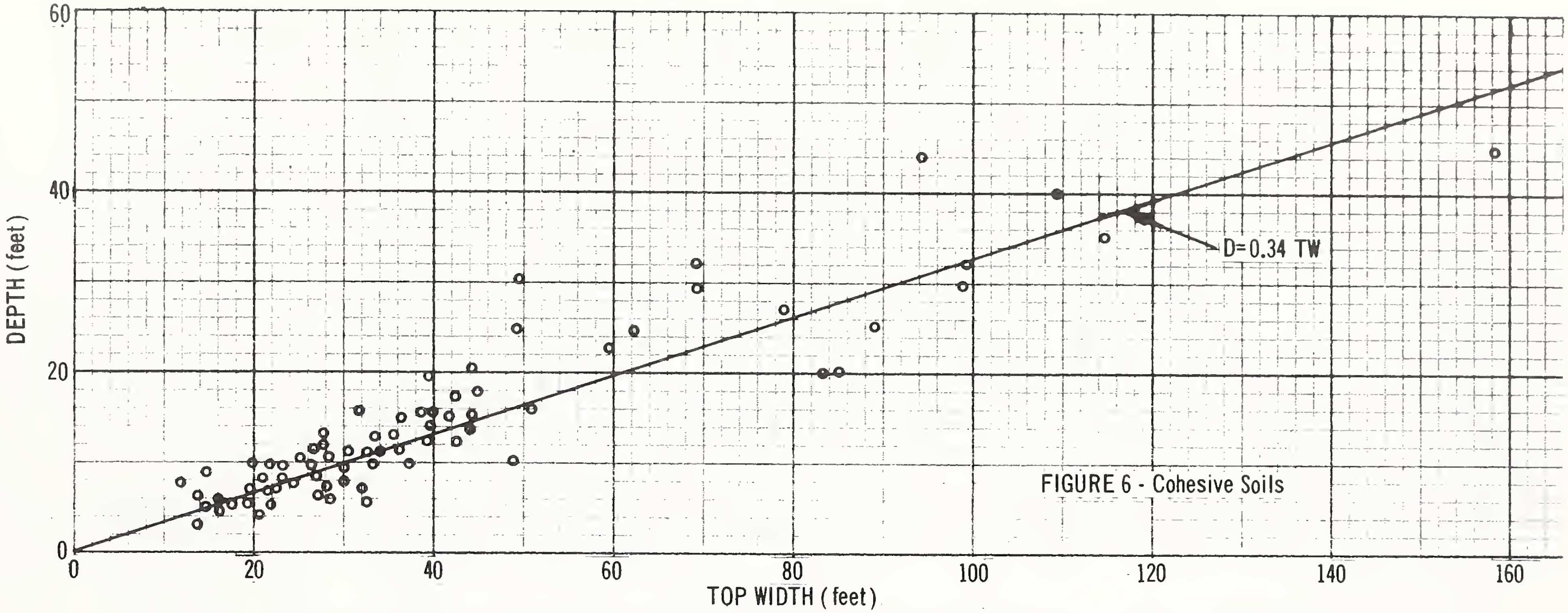
Damage

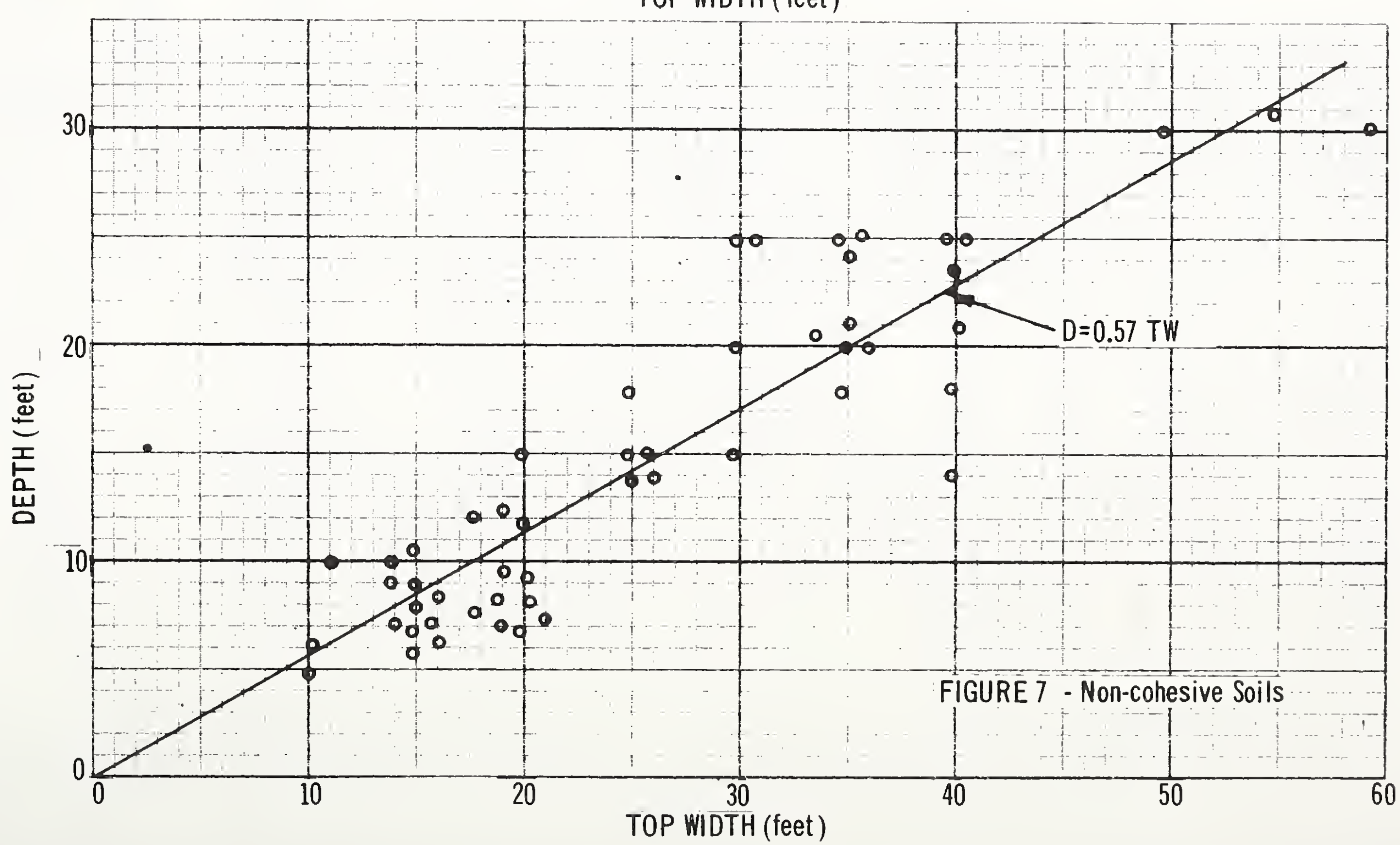
Land Damage

Since damage is physically expressed in terms of the area voided by the gully system, the future gullied area as determined in the procedure above represents the land damage area. This area, in terms of acres, is to be provided the economist for evaluating land damage.

Land Depreciation

The determination of future land depreication is a joint responsibility of the economist and the geologist. To assist in this determination,


DEPTH (feet)
TOP WIDTH (feet)
D=0.34 TW
FIGURE 6 - Cohesive Soils


DEPTH (feet)
TOP WIDTH (feet)
D=0.57 TW
FIGURE 7 - Non-cohesive Soils

the geologist will provide a map or a sketch showing the expected extent of gully development at the end of a fifty-year period or lesser period if maximum development occurs before the end of the fifty-year period. In the latter case the actual period should be shown. This includes the main gully and its expected tributaries. Boundaries of expected gully development, including tributaries, are to be shown on maps or drawings with solid lines. The boundaries of all depreciated areas are to be indicated by broken lines. Aerial photographs, soils maps, land capability maps, and land use maps are ideally suited for this purpose because of the additional information they register. However, base maps and topographic maps are acceptable. Approximate property boundaries added to the map or sketch aid in determining depreciated areas.

The geologist can be particularly helpful in delineating depreciated areas where physical conditions will be altered with resulting depressed yields due to gully development. Thus, if a future gully channel advances to a point where it intercepts and lowers a ground water level to the extent that depressed yields will result, the approximate area of influence should be delineated for computing depreciation. For example, it is not unusual for the gullying of mountain meadows to lead to the replacement of grass land cover with less desirable species such as sage.

Gully head advancement may depreciate sizable areas by restricting accessibility or intensity of land use. Thus, a cultivable border strip adjacent to a gully and areas between closely spaced gullies may be left idle because they are not readily accessible for machinery. Cultivation of these areas is not practical or economically feasible. Where gullies cross farm boundaries isolating fields so that they are inaccessible except by circuitous routes or requiring easements for access, such areas also are depreciated.

Gully head advancement up a natural draw or waterway which might serve as a present or potential terrace outlet for terraceable land depreciates all of the land which would be served by the terrace outlet.

Other Damage

Where potential gullies move headward to a road culvert, it is to be assumed that such headward advancement will be halted at this point. In respect to road bridges, however, such advance may continue headward beyond the road resulting in undermining the bridge and necessitating high maintenance or costly replacement.

There are other forms of damage such as potential damage to farm buildings and other structures. In all cases the geologist and economist must work together to anticipate and evaluate potential damage.

Sediment Production

The sediment produced is computed from the total amount of gully void reduced to an average annual rate. The volume of void can be computed by multiplying the area of land damaged, as computed previously, by the average depth. This should be done by reaches if the gully is not of regular shape. Tributaries should be computed individually. The volume of void then must be converted to equivalent weight in order to express the sediment produced in total tons or tons per unit area.

Where land damage and depreciation are not being evaluated, other methods are to be used to determine sediment yield for sediment storage requirements or evaluating depositional damages. The use of this procedure is not required for sediment yield computations because in most instances, particularly in larger watersheds, the amount of sediment derived from gully erosion is usually only a minor part of the total which includes that derived from sheet erosion. The minor differences which would result in the total does not warrant the additional work involved in this procedure for refinement of results.

Where sediment yield derived from gully erosion is computed for evaluating downstream sediment damages, judgment must be used in determining the delivery ratio of sediment in respect to the location of downstream sediment damage areas.